DOCUMENT RESUME

ED 239 901 SE 043 857

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TITLE	Understanding Electricity. Teacher's Guide. Unit 11. ZIM-SCI, Zimbabwe Secondary School Science Project. Year 2.
INSTITUTION	Ministry of Education and Culture (Zimbabwe).; Zimbabwe Univ., Harare. Dept. of Curriculum Studies.
PUB DATE	Aug 83
NOTE	43p.; For study guide, see SE 043 856; for related documents see SE 043 827-859.
AVAILABLE FROM	Univ. of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Electric Batteries; *Electric Circuits; *Electricity; General Science; Measurement Equipment; *Science Activities; Science Education; *Science Experiments; Science Programs; Secondary Education; *Secondary School Science; Teaching Methods; Units of Study
IDENTIFIERS	*Zimbabwe Secondary School Science Project

ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be read in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments in a two-part unit dealing with various aspects of electricity. Major areas investigated include: simple circuits; conductors and insulators; electric symbols; series and parallel circuits; measurement of current in series and parallel circuits; measurement of electrical energy; short circuits; fuses; resistance; and voltage, current, and resistance. Each section in this guide corresponds to a given section in the student study guide. (JN)

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ZIM-SCI

ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

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YEAR 2

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TEACHER'S GUIDE UNIT I 1

UNDERSTANDING ELECTRICITY

SE 043 857

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

v. 2

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ACKNOWLEDGEMENT: We are grateful for the considered advice we have received from the Regional Education Officers (Science) in the preparation in this unit.

AUGUST 1983

The following symbols which appear only in the Teacher's Guide are used to indicate important points for you the teacher.

Take note of an important point.

This symbol indicates a preparation of apparatus which should be done well ahead of time. Please read these notes carefully and carry out the instructions well in advance.

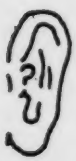
We have placed this symbol next to experiments where we feel there may be a possible danger. Please read the section carefully so that you know about the particular danger in that experiment. It would also be wise to refresh your memory on the appropriate safety or first-aid procedures described in the Zim-Sci Handbook.

This symbol appears next to activities which are not experiments but involve pupils in observation and perhaps collecting information. An example is the field trip.

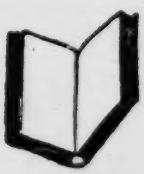
The following symbols will be used to indicate the points in the lesson at which teacher activity is particularly important. These symbols also appear at the corresponding points in the pupil study guides.

Practical work. The necessary instructions for each experiment will be given to you when you see this symbol.

Written exercises for the pupils. If possible these should be put on the blackboard before practical work begins so that the pupils can see what to look for.



Teacher information. The pupils will need extra guidance at these points. The information they will need from you is given where you see this symbol.



This symbol appears at a point where it is necessary for pupils to think over what they have done in the past few lessons. Set aside a period for this review activity. Encourage the pupils to read over their notes and the study guide section which they have just covered. It may be helpful to ask them to write a summary too.

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AIMS OF THIS UNIT

ELECTRICITY

At the end of this section pupils will be able to:-

(i) distinguish between conductors and insulators.

(ii) identify and draw a simple D.C circuit, including a switch.

(iii) distinguish between current as a flow of electricity and voltage as the measure of its ability to do work.

(iv) explain resistance by analogy with friction.

(v) distinguish practically between series and parallel circuits.

(vi) demonstrate how current voltage and power can be measured in simple circuits, and read a household electricity meter.

(vii) explain the relationship between current, voltage and resistance.

(viii) design simple experiments to observe heating and lighting effects of electricity.

(ix) explain the use of fuses, and why it is dangerous to overload any circuit.

(x) demonstrate how to wire a three pin plug and explain the function of the earth wire.

(xi) state the relationship between power; energy and time so as to have a basis for calculating electricity costs.

(xii) interpret simple household circuit diagrams.

(xiii) explain that an electric current has a magnetic effect.

(viv) describe how electricity can result from energy conversions and vice versa.

These aims are for both Units I_1 and I_2 on electricity. The aims in the Study Guide have been simplified and augmented for easy understanding by the pupils. They are basically the same as the ones above.

CONCEPT DEVELOPMENT

Introduction:

Electricity produces electrical energy that finds many uses in homes, commerce, industry and mining. Electrical energy can be converted into other forms of energy.

Simple Circuits

To light a torch bulb electrical energy is required. This energy requires a complete path circuit which consists of a battery, a bulb and a switch connected to the leads.

Conductors and Insulators

The circuit referred to above should consist of materials that allow electricity to pass through it. Those materials (which form the circuit) that allow electricity to pass through them are called conductors. Most metals, some solutions (electrolytes) and carbon conduct electricity. Other materials (mainly non-metals) do not conduct electricity and these are called insulators (non-conductors). A substance included in a circuit is a conductor if the bulb lights and an insulator if the bulb does not light.

Electrical Symbols

Electrical circuits are usually drawn in symbols which save a lot of time compared to the actual diagrams of the different parts of the circuit. From now on most circuits will be drawn in symbols which are introduced at the appropriate time in the Unit.

The direction of current is included to help students understand the cell/battery symbol better.

Series and Parallel Circuits

Most simple cirsuits seen so far consisted of a cell and a bulb. Now two cells and two bulbs are included in the Series and Parallel circuits. Students investigate the energy output of both circuits and the advantages of using a parallel circuit instead of a series circuit.

Measurement of Current in Series and Parallel Circuits

The ammeter, which measure electric currents, is introduced into circuits. In order to measure currents (D.C.) it must be connected correctly. This is why the direction of flow was introduced earlier on. A water analogy is used to explain why an ammeter is connected in series with the circuit. The instrument is then placed at different parts of both series and parallel circuits. Readings are taken and analysed so that general statements about currents in the series and parallel circuits may be formulated.

Measurement of Electrical Energy

The concept of potential difference (p.d.) is explained in terms of available electrical energy. The concept is also supported through the use of an anology. The voltmeter which measures electrical p.d. is introduced. The voltages of cells on an open circuit are measured and this is followed by measuring p.d. across different parts of the series circuit. Becasue a voltmeter measures p.d.across different parts of the circuit it is connected parallel to the circuit.

Short Circuits

When does a short circuit take place?
To conserve electrical energy a teacher demonstration will be carried out using a rechargeable cell whose rate of discharge is measured before and after the short by a torch bulb. The concept is then explained by means of an analogy.

Fuses

Using the steel wool as a fuse pupils investigate the action of the fuse by short-circuiting the bulbs in a circuit. This is reinforced by a teacher demonstration using a 5A fuse wire which will amply show the use of a fuse in a circuit. Finally pupils look at the catridge fuse.

Resistance

What happens when electrical energy is converted to heat and light?

A pupil model activity of a circuit is done to bring out the concept of resistance. This is followed by an explanation of what happens in the torch bulb. The idea of resistance is used to distinguish conductors from insulators.

Voltage, Current and Resistance

The unit ends with a description of the relationship between voltage, current and resistance which are the fundamental concepts to understanding electricity.

N.B.

Important Information

These Units centre around the cell(s) in battery box, the circuit board, leads, connectors, bulbs and ammeter-voltmeter.

1. BATTERY BOX

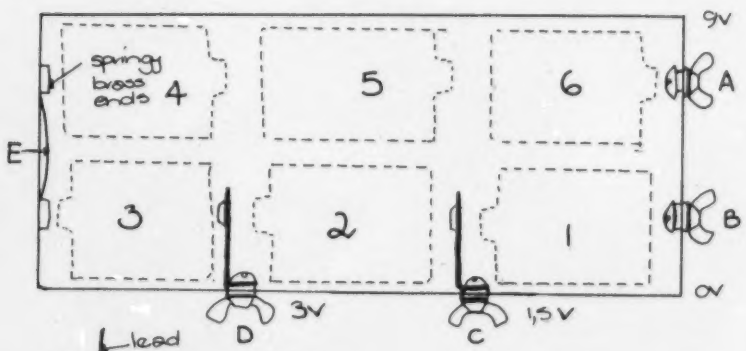
Each new battery box has information on how to assemble the box and to fit in the cells. In case the information is not available the same information is provided here for you.

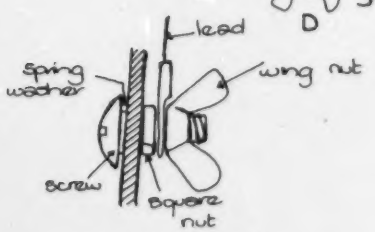
BATTERY BOX ASSEMBLY INSTRUCTIONS

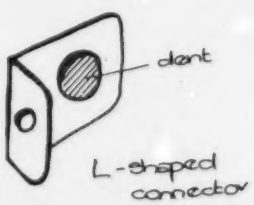
Insert two of the screw with circular spring washers into the outer holes in the end of the battery box. Fix on the square nuts and tighten them using a small screwdriver before adding the wing nuts as shown in the diagrams. Put in six batteries in series following the pattern in the bottom of the box. The plastic bubble sheet can be used to prevent the batteries moving about. If the springy brass ends get bent back too far and so fail to make good contact with the batteries, they should be bent outwards a little.

USE FOR EXPERIMENTS REQUIRING 1.5V AND 3V OUTPUTS

The battery box can be adapted to provide 1.5V and 3V outputs by fixing the two L-shaped plates to the side of the box with the screw assembly as previously described. If desired, self-adhesive labels can be added to show the 0,1.5,3 and 9V output terminals.







Assemble one yourself the day before so that you can help your pupils effectively when they assemble their boxes. Once the pupils have assembled the boxes there is no need to pull the parts apart for storage. It may be an idea to number the boxes 1 - 20 so that the same pair would use the same box throughout the unit and also in case of a loss you can easily tell which pair misplaced/ lost its box.

In Unit 1_1, the greatest number of cells used is 3. This means that cells 4 - 6 are never used. They are there to keep cells 1 - 3 in position. To ensure that pupils do not use all the cells (9V) it may be a good idea to cover the head A of the nut with cellotape once the box has been assembled. Do this when pupils are away. Telling them not to use all the cells will not help - children are children as you well know!

To assemble a circuit with:

a) one cell connect leads to wing nuts B and C or C and D.

b) two cells connect leads to B and D

c) three cells, open the box and connect the leads to B and E (the wire joining the springy brass ends).

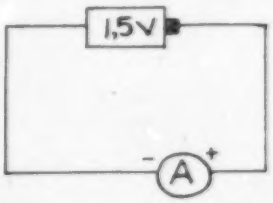
2. CELLS

The success of the Unit depends upon the availability of good cells. If you are not very careful pupils can make the cells in the battery box go flat in no time. I would suggest that you tell the pupils NOT to connect the ends of a cell/s directly with a lead without a bulb/s in the circuit. The first lessons are very crucial because pupils are excited and are prone to do things you do not expect them to do. Keep a watchful eye and instil in your pupils the idea that they should complete their circuits for a short time - enough time to make an observation or take a reading - so as to prolong the life of the cells. Do not allow your pupils to use more cells than the experiment requires as this will be wasteful. When cells 1 - 3 are flat ask pupils to swop these with cells 4 - 6 which should be good.

HOW TO TEST YOUR CELLS

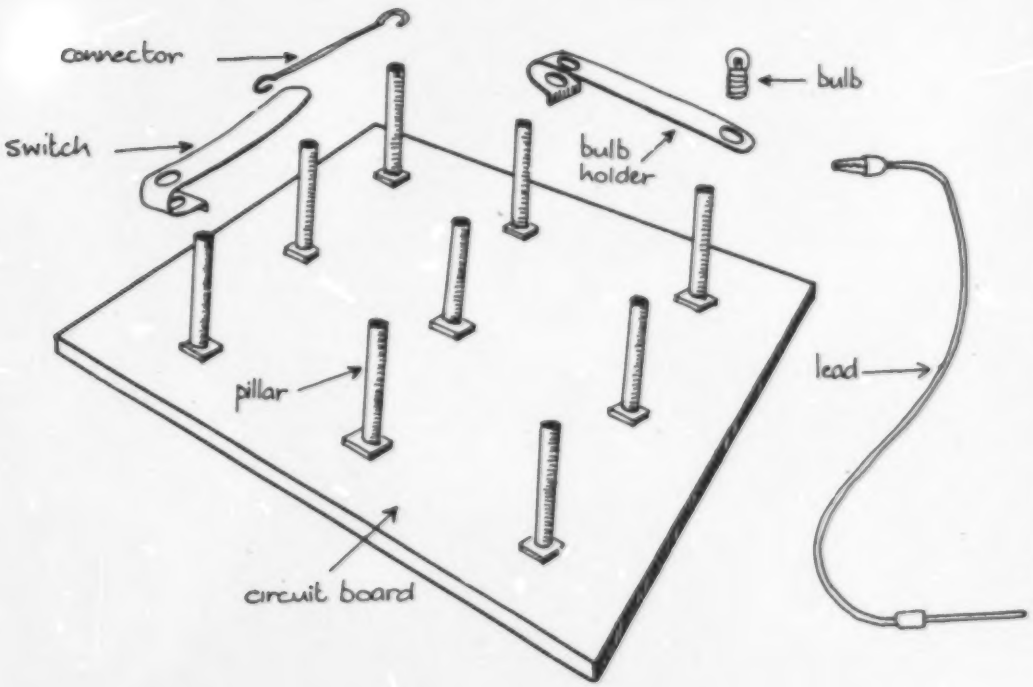
The fact that cells have been sealed in a box does not necessarily mean that they are fully charged i.e. they are new. They may look new but may be old and so will not provide the required voltage and current. I have discovered that using a voltmeter is misleading in the sense that the voltage may be very nearly 1,5v but the current which can be delivered may be lower than 0,2A. If used in an experiment which requires new cell/s the experiment won't work. The surest way is to test the current of each cell. Each new cell has the ability to deliver a current which is MORE THAN ONE AMPERE (1A) or very close to 1A. To test the cell, touch MOMENTARILY the terminals of each cell with ammeter leads.

If the cell is new the pointer sweeps across the scale or moves very close to 1A. If the cells are already in the battery box then test each one by touching B and C, C and D and D and E.



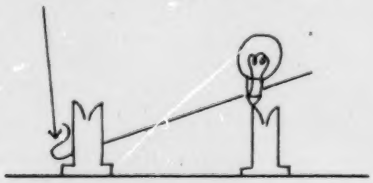
It will be a good idea to teach one/two pupils to do this for you. This/these two will test the required cells the day before for the following day's experiments. If you can train one or two pupils to be your 'lab technicians' it will make your lesson preparations a lot easier!

3. <u>THE CIRCUIT BOARD</u>



The circuit, page 4 of S.G., is important in assembling the circuits. A few hints on it might be of some help to you.

(a) Always make the bulb sit at the edge of the pillar as on pages 8 and 9 in S.G. This ensures proper contact. The bulb should rest firmly on the pillar. If it is not, bend the bulb holder until it does. If you still cannot make a firm connection try turning the holder upside down thus:

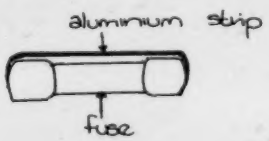


(b) If the plug end of the lead fits loosely in the pillar hole you should push the switch/bulb holder blade between the two metal strips and turn it slightly to separate the pieces. Remove the switch/holder and insert the plug into the hole. It should fit in firmly now.

(c) Make sure the lead is firmly connected to the crocodile jaw and the plug.

4. AMMETER-VOLTMETER

These instruments are very delicate. Stress to your pupils that these should be used with great care. Each instrument is protected by a fuse. Fuse caps are easily seen at the back of both instruments. Should the fuse blow and you don't have a cartridge fuse to replace it I suggest you cut a thin strip of aluminium foil and bridge the metal caps of the fuse and then fit it back to the instrument. ONLY DO THIS AS AN EMERGENCY REPAIR.



I must point out that this action DOES NOT protect the instrument. The proper fuses "blow" at 1,25A for the ammeter and 0,05A for the Voltmeter. The instrument will be damaged before the fuse blows. It is advisable to have suitable spares. In future years a few spare fuses will be included in the resupply kits for Year II.

5. LIGHT BULBS

Use your 'lab technician/s' to test these bulbs to see if they light the day before the lesson. Try to ensure that pupils are given bulbs which give the same amount of light under the same conditions. There is nothing as frustrating as pupils coming to you for bulbs when they should be spending time gainfully!

In conclusion allow me to say that for your morale and the sustenance of pupils' interest you are strongly advised to CARRY OUT each experiment the DAY BEFORE, so that you are aware of the problems your pupils are likely to come up with. In this way you are able to solve problems well in advance or are able to suggest alternatives in good time. All the experiments in this Unit have been designed to work BUT, some may not work under your particular circumstances and so if you try them before, you are in a better position to point out why the experiment does not work and it will help you to conduct meaningful discussions.

EMPHASISE PUPILS MUST CONSERVE ELECTRICAL ENERGY THROUGHOUT THE UNITS (1_1 and 1_2).

In previous T.G.'s, a list of apparatus for Experiments in S.G.'s was included. In this Unit and the next I assume that you use both the T.G. and S.G. together to avoid repetition of these in T.G. All I have included in the T.G. are relevant information/the snags which pupils may encounter. However, a list of apparatus has been included for demonstration experiments. Experiments (in S.G.) which are straight forward i.e. no problems anticipated have been left out in T.G. so use both Guides when preparing for the next lesson/s.

DETAILED NOTES

Page 2: There are in fact two answers to my question on 'common energy', namely, electrical and light energy. I overlooked this when writing the Unit, for our purpose electrical energy is the important one.

Activity 1 Page 2

Uses may include:

In motor cars, electric trains, bicycle lamps, lighting homes, in refrigerators, in electric stoves/cookers, toasters, milking machines, telephones, television, robots (traffic lights), X-rays, aeroplanes etc.
The limiting factor is the pupils' environment. You get more uses from children in urban than from very remote areas.
A few examples are neededto emphasise the diversity with which electrical energy can be used.. Rub the board and then write the Exercise on the board for pupils to do.

N.B. Every Exercise must have a heading. This will help pupils during revision.

Exercise 1 Page 2.

ELECTRICITY

Electricity produces ..... A few examples of the uses of this energy are:

(1)

(2)

(3)

(4)

(5)

Answers: Electrical energy or just energy.

1 - 5 Any five including those just rubbed off the board!

N.B.

CELLS Page 3

Provide each pair with a cell, and point out that these are cells not batteries as they are often called. This cell (just a unit) has nothing to do with cells in living things.

EXPERIMENT 1 Page 3

If you do not have pieces of copper wire use the lead for the circuit board. When copper wire is available make sure that the ends are not insulated. If the copper wire is insulated use emery paper, from the electric motor kit, to remove the insulation. Do not allow pupils to connect the terminals of the cell together directly with the wire lest the cell is discharged quickly. (See page 44 in S.G.)

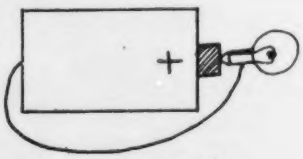
Exercise 2: Lighting a torch bulb Page 4

1. Draw a diagram of the assembled apparatus when light is produced.

2. Write the summary from the S.G. page 4.

Answers

1. As per pupil's diagram. →



2. As in S.G.

Page 4

CIRCUIT BOARD

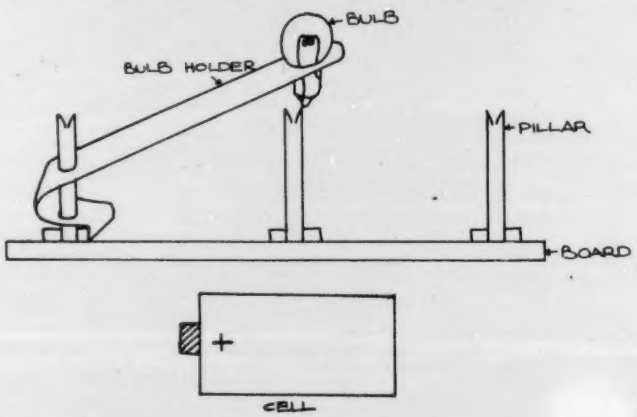
This is the first time that the pupils come across the circuit board. Provide each pair with the board and accessories. Let the m identify each piece of apparatus. You give them time to practise fitting the accessories to the board and the bulb to the bulb holder. Show them how to make the lead plug fit in firmly to the pillar holes . This leads to Experiment 2.

Page 5

EXPERIMENT 2: Lighting a torch bulb using a circuit board

This experiment should not be difficult for students. But what you should stress is that a complete circuit is necessary to light the bulb. Show them how the bulb rests on the pillar.

Exercise 3: Lighting a torch bulb on circuit board Page 5



(1) Copy the diagram above. Draw leads to complete the circuit.

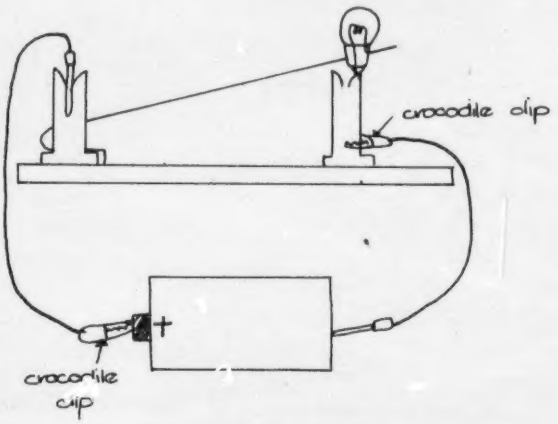
(2) The complete circuit consists of ..... , ...
..... and .....

(3) Which is the source of electrical energy in the circuit?

(4) Which part of the circuit converts electrical energy into other forms? Name the two forms.

Answers

1.



Do not be fussy about how good the diagram is.

What is important is the complete circuit.
Point out that the battery box is NOT needed.

2. The cell, the leads, the bulb holder and the bulb.

3. The cell is.

4. The bulb. It converts electrical energy to heat and light.

Page 5

THE SWITCH Page 5

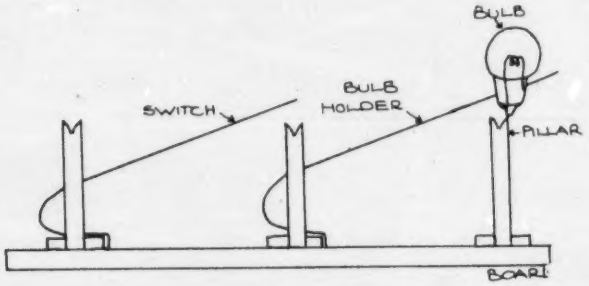
Find from your pupils what the switch is used for in a circuit. Then let them fit it in the circuit as in Experiment 3.

EXPERIMENT 3: Use of a switch in a circuit Page 6

Let the pupils carry out the experiment on their own using the instructions. When the circuit is assembled, the bulb should not light as the switch is on the "OFF" position. To light the bulb they should press the switch. The pupils will be in a position to tell you the use of a switch in a circuit, It may be possible the switch has been bent so that when connected to the circuit it completes the circuit. Go to the pair and straighten the switch/tell them to do so.

Exercise 4: The Switch Page 6

Teacher: Please ask the students to time themselves (in whole minutes) when they draw and complete the diagram in Question 1 below. This time will be needed later (on page 11 in S.G.) when considering electrical symbols as a way of speeding up drawing circuits.



(1) Copy the above diagram into your notebook.
Draw leads to connect the cell to the bulb and the switch.

(2) I took ..... minutes to answer Question 1.

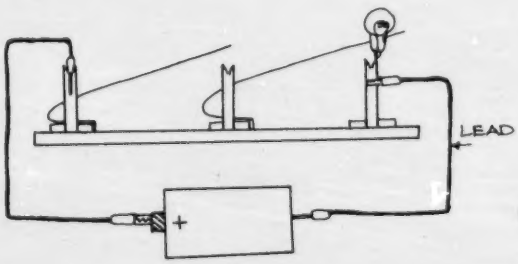
(3) The circuit above is an ..... circuit because the switch is in the ..... position.

(4) To complete the circuit I ..... down the .....
The circuit is complete when the switch is on the ..... position.

(5) The use of a switch is to ..... or ..... the circuit.

Answers

(1)



(2) Open/Incomplete, off.

(3) Pressed/Pushed, switch, on.

(4) Complete, break or vice versa.

Note again that the emphasis is still on the circuit not on good diagrams.

Page 7

EXPERIMENT 4

Provide materials kit etc. as in pupils guide.

Page 9

EXPERIMENT 5

(1) Prepare salt solution as follows:
Dissolve 30g in 1 000ml of water.

(2) Cut 40 aluminium strips measuring 2cm x 5cm.

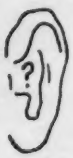
(3) Dilute hydrochloric acid: If you do not have dilute acid prepareit as per G_1 Teachers' Guide page 11.
Make sure you have enough for your class.
You will probably need about 600ml.

Pages 7 and 9

CONDUCTORS AND INSULATORS

EXPERIMENTS 4 and 5

Discussion



In the discussion ask pupils whether they know if there are other substances, apart from the conductors they have used so far, which allow electricity to pass through them. They should tell you why they think so. Then let them investigate whether the materials suggested for Experiments 4 and 5 conduct electricity. These two experiments need thorough planning beforehand lest a lot of time be wasted looking for various articles. Make good use of your 'lab technicians' to make life easier for yourself.
With liquids (salt solution, methylated spirits, acid) make sure pupils pour out each one after testing, wash the beaker with water, dry it and then pour in another liquid.

Exercise 5: CONDUCTORS AND NON-CONDUCTORS (INSULATORS)

N.B. The answers in this table are for your guidance only!

(1) Draw the table below and fill in as you go.

1 Material/ Substance	2 Torch bulb glows		3 Brightness of Light			4 Conductor/ Insulator		5 Metal/ Non-Metal	
	Yes	No	Nil	Dim	Bright	Conductor	Insulator	Metal	Non-Metal
Copper	✓				✓	✓		✓	
Aluminium	✓				✓	✓		✓	
Iron	✓				✓	✓		✓	
Mild Steel	✓				✓	✓		✓	
Perspex		✓	✓				✓		✓
Polythene		✓	✓				✓		✓
Polystyrene		✓	✓				✓		✓
Rubber Foam Cube		✓	✓				✓		✓
Thin Spring (Steel)	✓				✓	✓		✓	
Thick Spring (Steel)	✓				✓	✓		✓	
Wood		✓	✓				✓		✓
Grass		✓	✓				✓		✓
Rubber Band		✓	✓				✓		✓
Connector	✓				✓	✓		✓	
Carbon Rod	✓			✓	✓	✓			✓
Water		✓	✓				✓		✓
Salt Solution	✓			✓	✓	✓			✓
Meths		✓	✓				✓		✓
Hydrochloric Acid	✓			✓	✓	✓			✓
Air		✓	✓				✓		✓

Note: Exercise 5 includes both experiments. If you have a double period both experiments can be done but if not do them separately. Let pupils only write down the materials they actually use, but make sure there are enough metals and non-metals.
Columns 1, 2, 3 can be answered as soon as the substance is tested.
Columns 4 and 5 will be answered after reading pages 10 and 11 in S.G.

N.B. Write down the rest of the following Questions after pupils have completed columns 4 and 5.
See S.G. pages 10 and 11.

2. How many solid substances are good conductors of electricity?

3. Within this group of solid conductors there is one which should not belong to this group but it does.
Which one is it?
Why do you think it should not belong to this group?

4. Which liquids conduct electricity?

5. Is a chemical or a physical change take place when electricity flows through a liquid? Explain your answer.

6. Look at the list below:
Glass, magnesium, screw, zinc, oxygen, candle wax, lead, foil.
Only write down the substances which are good conductors.
Give a reason why you think these are conductors.

7. Generally ..... are good conductors of <u>heat</u> and <u>electricity</u> whereas .....are generally .....

<u>Answers</u>

1. See table above.

<u>Note</u>: <u>Column 2</u> Because water is not chemically pure it might just conduct electricity hence bulb might glow dimly. In this case it might act as salt solution.

<u>Column 3</u> If the substance is a conductor accept either dim/bright e.g. salt solution and acid.

2. 7, or as per pupils' list.

3. Carbon rod because it is not a metal.

4. Salt solution, hydrochloric acid.

5. A chemical reaction because some gases were produced when electricity flowed through them.

6. Magnesium, screw, zinc, lead foil because they are all metals.

7. Metals, non-metals.

Page 11

N.B.

ELECTRICAL SYMBOLS

Straightforward.
A chart on electrical symbols covering the 4 years is under preparation. The intention is to gradually move pupils from 'representative' diagrams to symbolic diagrams. In order to help the pupils make this transition we have sometimes included both types side by side for the same circuit.

IN SOME CIRCUITS A SWITCH WAS LEFT OUT. WHEN PUPILS ASSEMBLE THE CIRCUIT ALWAYS INSIST THAT IT BE INCLUDED AS ITS INCLUSION CONVSERVES ELECTRICAL ENERGY.

Page 13

DIRECTION OF FLOW OF ELECTRICITY

Stress the fact that it is only a convention that electricity flows from the positive to the negative. (In fact electrons flow in the opposite direction. Pupils will learn this in Year III).

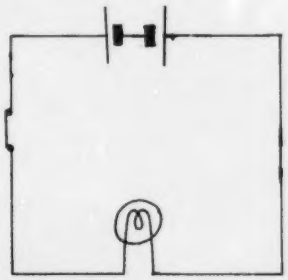
Page 15

Exercise 6: ELECTRIC CIRCUITS

(1) ..... are used to represent parts of an electrical circuit.

(2) Draw an open circuit which consists of three cells properly connected, a bulb and a switch.

(3)



The circuit above is a complete one.
Study the circuit carefully then answer the following questions.

(a) Draw the circuit into your notebook.

(b) What type of circuit do you have?

(c) Does the bulb glow? Give a reason why it does or does not.

N.B.

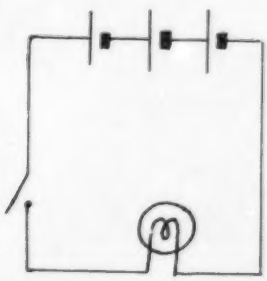
Teacher, let your students answer (c) by reasoning and then let them quickly find out by experiment after question 4. The result may be startling!

4. In a complete circuit, electricity flows from ..... to the .....terminal.

Answers: 1 Electrical symbols or symbols

1. Electrical symbols or symbols.

2.



3. (a) ^

(b) A complete circuit.

(c) No. Cells are connected wrongly or no current will flow since the voltages oppose each other.

4. Positive, negative.

Page 16

EXPERIMENT 6: Connecting cells in circuit

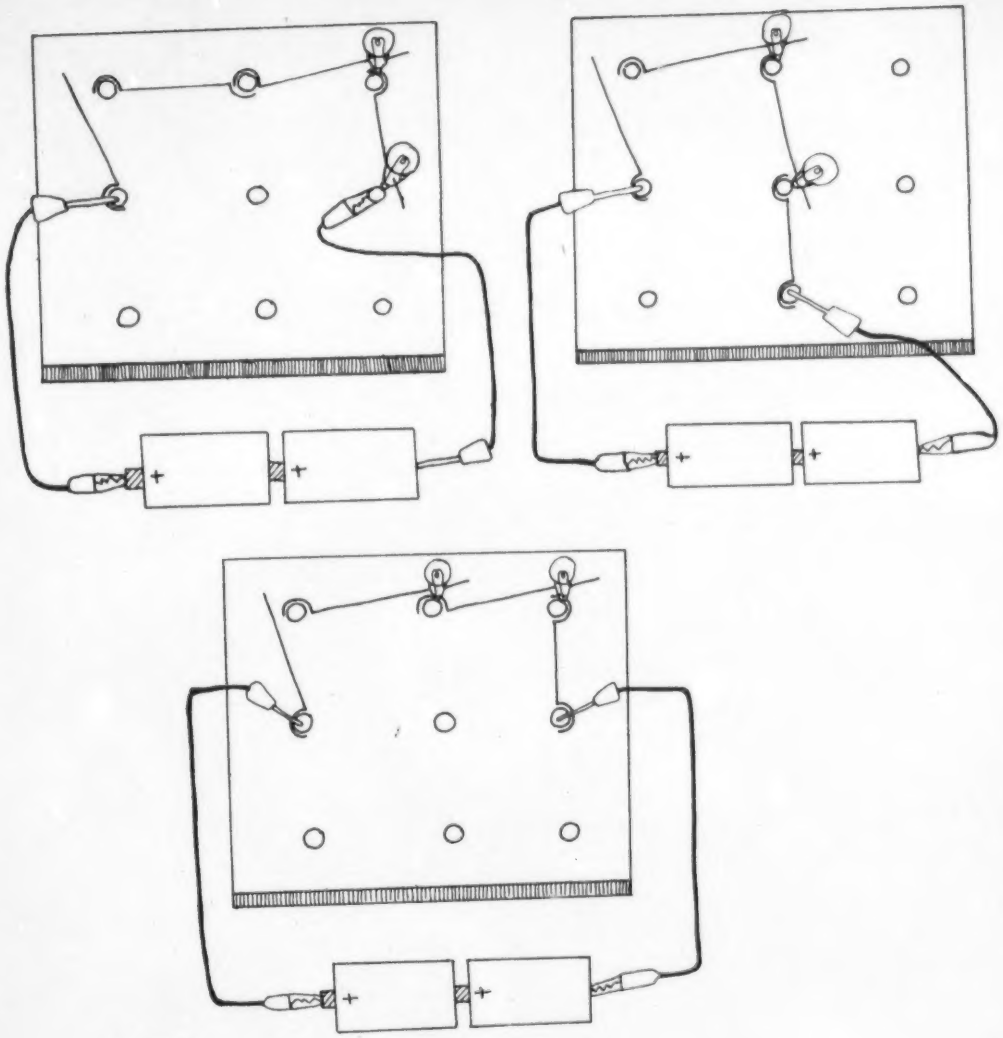
Provide items as in S.G.

Page 18

EXPERIMENT 7: Bulbs in series

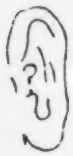
Write down Question 1 of Exercise 7 on the board.
This experiment introduces bulbs in series. The circuits are not provided in the S.G. It is the pupils' task to light these bulbs. Let them have a go at it with the apparatus provided. Keep a watchful eye on your groups for short circuits which will run down the battery quickly. Your help, in form of suggestions, should only come, when sought, when a group is not making any headway.

The following diagrams are included as possible circuits your pupils might assemble. Assemble them yourself the day before so that you can help your pupils effectively.



Page 19

Discussion



Whatever circuit/s your pupils might assmeble, bulbs in SERIES will glow when the circuit is complete BUT if one of them is lifted the other one will not light since the circuit is broken at that point. This suggests that the same electricity (current) flows through both bulbs.

Page 19

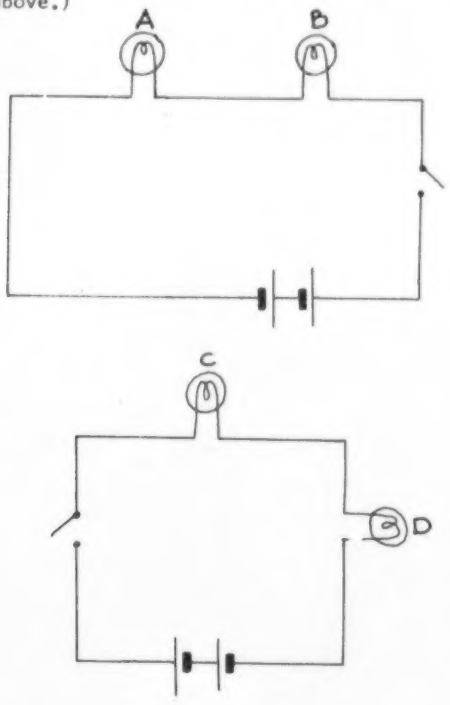
Exercise 7: Series connections in cells and bulbs

1. My successful circuit diagrams are: (expect 2 circuits)
   Pupils draw each successful diagram, in electrical symbols, before trying another assembly.

   The rest of the Questions to be put on the board after answering Quesiton 1 and the discussion.

2. (a) Draw in symbols, two cells connected in series.
   (b) Two cells are connected in series when the ..... of one cell is connected to the ..... terminal of the other cell.
   (c) Two or more cells connected in series form a .....

3 (a) Draw the following circuits into your notebook. (Compare these circuits with your circuits in Question 1 above.)



   (b) When the circuits are complete both bulbs in each circuit .....
   (c) When bulb A is removed, B does .... because the circuit is ..... at A.
   (d) When D is removed from the circuit, C does ..... light because the circuit is ..... at D.
   (e) In a series circuit which is complete, the same ..... flows through both bulbs.

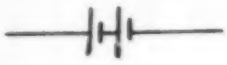
4. Are the bus or car headlamps connected in series? Give a reason for your answer.

5. The two series circuits above would not be very suitable for lighting two separate rooms in a house. Give two reasons why you think the series arrangement would not be very suitable.

Answers

1. As per pupils' circuits or as in 3(a).

2. (a)



(b) Positive/negative, negative/positive.

(c) Battery.

3. (a) As in the diagram already given.

(b) Glow.

(c) Not glow, broken/open/cut.

(d) Not, broken/open/cut.

(e) Electricity/flow.

4. No, because one bulb can still light when the other one is blown or removed.

5. (a) Both rooms will be in darkness if one bulb blows.

(b) Both rooms will be lit when only one needs to be lit and this will be a waste of energy.

Page 20

EXPERIMENT 8: Parallel Circuit

This experiment is similar to the previous Experiment in that pupils will assemble the circuit themselves. Only help them when they are in dire need.

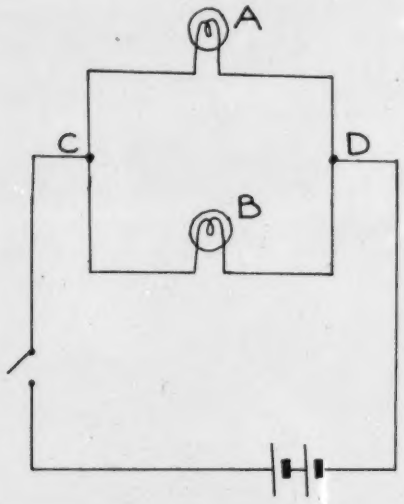
Let your pupils draw their successful circuit as an answer to Question 1 of Exercise 8.
Draw pupils' attention to the paragraph below Experiment 8 on page 21 in S.G.

Page 21

Exercise 8: Parallel circuit

1. Draw the diagram of your successful circuit in symbols. Put the rest of the Question of this Exercise after each pupil has drawn the circuit of Question 1.

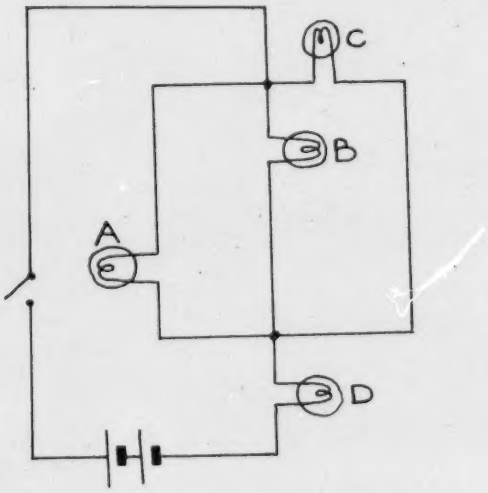
2. (a) Draw the circuit below into your exercise book. (Compare it with your circuit above.)



What happens to electricity at C when the circuit is complete?

(b) In a ..... circuit bulbs will not go off if one of them blows or is removed because each bulb has its own branch ..... which will still be .....

3. (a) Draw the following circuit and then answer the following questions.



(b) When the circuit is complete, what will happen to the other bulbs if (I) B is removed? Why?
(II) A blows? Why?
(III) D blows? Why?

(c) Are bulbs A, B and C connected in series/parallel? Give a reason.

(d) Is D connected parallel/in series with A, B and C? Give a reason.

4. Which circuit is used to light bus/motor car headlamps and different rooms in a house?
Give a reason.

Answers

1. As per pupils' circuit.

2. (a) As in the diagram already given.

The current divides in two.

(b) Parallel, circuit, complete.

3. (a) As in the diagram already given.

(b) I. The rest of the bulbs will still light because it is only B's branch circuit which is broken/open.
II. The rest of the bulbs will still light because it is only A's circuit which is open.
III. All the bulbs will not light because the main current passes through D/because D is connected to the main circuit.

(c) Parallel because each one has its own branch circuit.
(d) Series because when D blows the whole circuit becomes 'dead'/incomplete/open.

4. The light bulbs are connected in parallel so that when one or more bulbs blow the rest will not be affected.

After this exercise go through the summary with your pupils and then ask them to write it down in their exercise books.

Page 22

EXPERIMENT 9

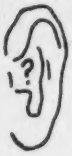
As in S.G.

You could read over pages 35 and 36 with the class.

Page 23

Activity 2: The Ammeter

Refer to Important Information at the beginning of the T.G.



Discussion

This ammeter measures currents between 0 and 1A. Each graduation represents 0,02A (2×10^{-2}A). Hence the instrument is quite an accurate one and VERY DELICATE.

The Zero Correction

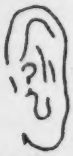
If the pointer is not at 0-mark adjust it by turning the screw (left/right) which is DIRECTLY below the A on ammeter scale. Use the edge of the bulb holder/the switch as your screwdriver.

Page 25

EXPERIMENT 10: Connecting the ammeter to a circuit

Pupils might find it difficult to interpret the diagram. Please help them.
For correct connection of the ammeter, refer to last paragraph on page 27 in S.G.

Page 27



Discussion

The pointer moved to the left showing that the current is now flowing in the opposite direction.
Emphasise the correct connection of the ammeter to a circuit.

Make sure the ammeter plugs are firmly plugged.
Refer to Important Important Information pages again.

Page 27

Exercise 9: Measurement of Electric Currents

1 The instrument used to measure currents in a circuit is called .....
A current which flows in a definite direction is called .....
To measure electric currents the ..... hole must be plugged with a ..... lead which is connected to the .....terminal of the battery and the ..... hole must be plugged with a ..... lead connected to the terminal of the battery.

Put Question 2 on the board after pupils have read Page 28.

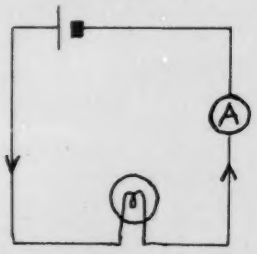
2 The circuit diagram on page 28 refers to the circuit of Part 1 of Experiment 10.

(a) Draw this circuit in your notebook.
(b) Draw the circuit diagram of the circuit on Page 26.
(c) What was the ammeter readings in circuit (a) and (b)?
(d) The current in a series circuit is ..... at any ..... in the circuit.
(e) The ammeter is connected in ..... with a circuit and the symbol is:

Answers

1. Ammeter, D.C. (direct current), red, red, positive, black, black, negative, OR black, black, negative, red, red, positive.

2. (a) As per S.G.
   (b)



(c) As per pupils readings which should be the same.
(d) Same, point/part of.
(e) Series,

Page 29

Water Current Analogy

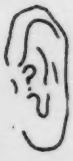
The cell/battery, the conductor and current correspond to the pump, pipe and water flow respectively. The water meter is connected in series.

Page 30

EXPERIMENT 11: Current measurement in more complicated circuits

Use a new cell and if not available then use two. Help pupils in the event of some difficulty in assembling circuit No. 2.

Page 31



Discussion:

Refer to last paragraph (***) on page 31 in S.G.

Page 33

Exercise 10: Measuring current in series and parallel circuits

1. (a) Draw circuit No. 1 of experiment 11 in your exercise book.

   (b) Draw the following Table into your exercise book and fill in your readings as you get them.

Ammeter Position	Current (A)
A_1	
A_2	
A_3	

(c) From the results in the Table above, I can conclude that the current in a series circuit is .....

(d) When Y is lifted the ammeter reads ..... A and therefore X will .....

2. (a) Draw the circuit diagram on page 33 and include the ammeter in position A_1.

(b) Draw the following Table and fill in your readings as you get them.

Ammeter Position	Current (A)
A_1	
A_2	
$A_1 + A_2$	
A_3	
A_4	

(c) From your results, what do you notice about the sum of A_1 and A_2 in relation to A_3 or A_4.

(d) Which ammeters measure the main current in the circuit?

3. If the readings of A_1 and A_2 are the same, what can you say about the bulbs' size and the amount of light energy each produces?

4. There is ..... current flowing through a ..... circuit than in a series circuit. The bulbs in a ..... circuit are ..... than the same bulbs in a series circuit. Hence ..... energy is produced in a ..... circuit than in a ..... circuit.

Answers

1. (a) Diagram.

   (b) As per pupils' readings. These should be the same since current in a series circuit is the same.

   (c) The same (throughout).

   (d) 0A (zero), not glow/light.

2. (a) A_1 should be anywhere in bulb X's circuit.

   (b) A_1 and A_2 as per pupils' readings. Their sum should be equal to the readings of A_3 and A_4 (the main current).

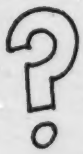
   (c) $A_1 + A_2 = A_3/A_4$.

3. Bulbs are of the same size and the energy produced by each is also the same.

4. More, parallel, parallel, brighter, more, parallel, series. More current delivering more energy to X and Y flows through a parallel circuit. The readings of A_1 and A_2 add up to A_3 or A_4.

Why does the same cell produce more current in this circuit than in the previous one? This has something to do with resistance which you cannot introduce here. Should pupils ask you this question tell them you will answer that after going through Pages 50 to 53.

Page 34



HOW MUCH DO YOU KNOW? 1.

N.B. Question 4 should read:

The current flowing through a ..... circuit is the ..... throughout the circuit.

Ask pupils to correct this in their Guides.

Answers

1. Complete.

2. Ampere, A, Ammeter, Series.

3. Current.

4. Series, Same.

5. Energy.

6. Parallel, main, two, add, main current.

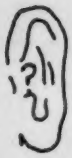
7. Remain or go on glowing, circuits complete, lights/bulbs, parallel.

8. Parallel, series, parallel, brighter, series, circuit, (electrical) energy.

9. Electrical, Light or Light and Heat.

Page 35

POTENTIAL ENERGY DIFFERENCE (p.d.)



It is probably the most difficult aspect of electricity. Do not try to hurry this part of the course. Each step is important in developing the concept. Read pages 35 & 36 with the class.
The diagram at the bottom of the page brings out the gravitation and potential energy difference which causes Jabulani's ball to roll whereas that of Faral does not because there is no potential energy difference. The transfer from this example to the cell as having a potential energy difference between its terminals which can cause a current to flow in the circuit may cause some misunderstanding in the minds of the pupils. They may think that a cell/battery must be UPRIGHT (always), with the positive terminal at the top, for a current to flow through a circuit. There is also a possibility of misconception in equating the physical size of the cell/battery with the corresponding magnitude of the potential energy difference. The physical size does NOT affect this magnitude. The manufacturers of cells/batteries use chemicals which provide the required potential difference. Your rechargeable cell has a p.d. of 2 volts (0,5v more than that of a torch cell) but can deliver up to 100A for a short time! (torch cell can deliver a maximum of about 1.5A.)

The reason for this difference is that the rechargeable cell has a very low internal resistance while the torch cell's internal resistance is quite high and gets higher as the chemicals are used up (see page 44 of S.G.) If the internal resistance is high much of the available energy is used inside the cell leaving only part of it for producing a current in a circuit.

The diagrams on page 36 show that the flow of current is independent of the position of the cell but is dependent upon the chemical reaction which takes place in the cell.

Page 37

THE VOLTMETER

See Important Information pages. Note that the chances of blowing the fuse of the voltmeter in these experiments are more remote than that in an ammeter.

EXPERIMENT 12 Provide apparatus as in S.G

Page 40

Exercise 11: Measuring available energy of cells

1. (a) The voltmeter reading of cell A is .....
B is .....
C is .....

(b)

Cells	Available Energy (volts)
A + B	
A + B + C	

2. (a) From the above results I can conclude that the available energy (volts) of cells connected in series ... .

(b) You are given a number of 1,5v cells. Your portable radio needs 9v to work. How many cells do you need for the radio?

(c) What do you think is likely to happen to your radio if you connected your cells so that their voltage is 15v? Why?

Answers

1. (a) As per voltmeter reading.

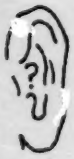
(b) A + B and A + B + C are the sums of voltages of the cells.

2. (a) Is the sum of the voltages of the cells/adds up.

(b) 6 cells - as in battery box.

(c) The radio is likely to be damaged because the higher voltage will deliver more energy to the radio than is required.

Page 40



Discussion:

The main idea of this short discussion is that when cells are connected in series, available energy increases. If the available energy is increased then it can cause a larger current to flow and more energy to be delivered to a bulb, for example, causing the bulb to glow more brightly or even 'blow'.

Page 41

EXPERIMENT 13: Energy changes in a circuit

This is the first time that both instruments are used in an experiment. Pupils might encounter some difficulty in connecting the voltmeter across various parts of the circuit. Do assist if need be.

Page 42

Exercise 12: Measuring energy changes (p.d.) across different parts of a circuit.

1. (a) Draw the circuit diagram on page 43 into your exercise book.

Voltmeter position	Voltmeter reading (V)
V_1	
V_2	
V_3	
V_4	
V_5	
V_6	
V_7	
V_8	

(b) Copy the table above and fill your results in as you get them.

(c) What do you notice about the sum of V_1 and V_2 compared to V_3?

(d) What do you notice about the sum of V_5 and V_6 compared to V_7?

(e) How much energy is required to drive the current through the (i) connector and
(ii) the ammeter?

2. Was all the available energy (V_3) from the battery converted to other forms of energy in V_7 and V_8?
If not, which energy reading is greater?
Which part of the circuit uses this energy?

3. Why is a car battery or your rechargeable cell a better source of electrical energy than an ordinary torch cell?

Answers

1. (a) Diagram As in the Study Guide.

(b) As per pupils' readings.

Here are my results (for 1. (b)) which I obtained when I did the experiment using new cells.

Voltmeter	V
V_1	1,4
V_2	1,4
V_3	2,8*
V_4	0
V_5	0,9 dimmer
V_6	1,4 brighter
V_7	2,3
V_8	0,05

(c) $V_1 + V_2 = V_3$

(d) $V_5 + V_6 = V_7$

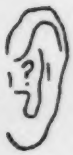
(e) i. Very little (less than 0,1v).
ii. No measurable energy (because the voltmeter pointer does not move at all.

2. No. That of V_3 is greater. The battery (cells) uses this energy to drive the current through itself.

3. It uses very little energy to drive a current through itself whereas a cell uses quite a large fraction of its available energy.

Page 43

Discussion:



It is the scientist's task to collect and analyse data. The reading of V_3 confirms an earlier finding. The total energy output is less than the total available energy. The part of the circuit that accounts for the deficit is the battery itself. It uses this energy to drive a current through itself. A poor source of electrical energy uses a lot of energy and a good source needs very little energy to drive a current through itself (see page 44 of S.G.)

The reading of V_4 needs a comment.
The instrument is not sensitive enough to register the very small amount of energy needed to drive a current through the connector. The connector/the bulb holder is a good conductor of electricity, hence very little energy is needed to let a current pass through it.

Charge fully your rechargeable cell for short circuit demonstration on Page 44 (See instructions in the Zim-Sci Solar cell booklet.)

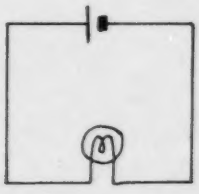
Page 45

SHORT CIRCUIT DEMONSTRATION

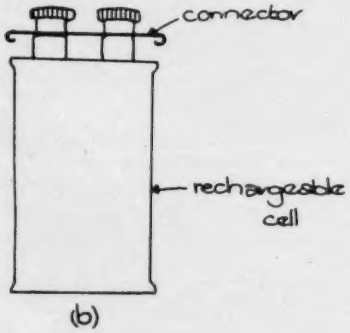
You will need:

a rechargeable cell (fully charged)
a connector
a circuit board
a bulb and holder
ammeter leads.

Assemble your circuit as in (a). Let the pupils note the brightness of the bulb. Then connect the terminals of the cell with a connector as in (b) for about 2 - 3 minutes then disconnect.



(a)



(b)

Ask one pupil to touch the wire soon after and let this pupil tell the rest how the wire feels. It should feel warm/hot. Repeat circuit (a) and ask pupils to observe the bulb. It may glow dimly/not at all.

Ask pupils to read pages 44 and 45 on short circuit once more. In (b) a large current delivering more energy passed through the connector hence it felt warm/hot.

N.B. You can start with the demonstration experiment first and then let your pupils read pages 44 and 45 later.

1. Make sure you have enough paper clips and steel wool threads for experiment 14.
2. Recharge your rechargeable cell for the FUSE demonstration on page 47 in the S.G.

Page 46

EXPERIMENT 14: Investigating Short Circuits

1. Please point out to the pupils that the bulbs are resting on the edge of the pillars. They were drawn as shown for clarity.

2. The steel wool thread joining the clips should be straight and thin as in the diagram. Have a surplus of steel threads as the pupils are likely to break some while tying.

3. Connecting a lead between A and B:

   By connecting a lead between points A and B electricity will pass through the lead (less resistance and hence an easier path) and so bulb X (a higher resistance) will not glow, but Y will glow much brighter. The circuit is now a simple circuit consisting of bulb Y only.

4. Connecting a lead between A and C:

   By connecting a lead between points A and C both bulbs are by-passed so that a large current now passes through an easy route (A SHORT CIRCUIT). This casues the steel wool to become hot and melt thereby breaking the circuit. This is the function of a fuse in a circuit - to break the circuit in the event of a short.

Page 47

Exercise 13: Short Circuits and Fuses

1. a) When does a short circuit happen?
   b) What will happen to a source of electrical energy when a short takes place?

2. What danger is caused to a building if a short takes place in a mains electricity circuit?

3. a) What is a fuse?
   b) How does it protect a circuit?

Answers

1 and 2 from the text.

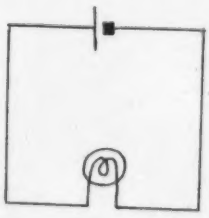
3. a) A fuse is a piece of wire included in a circuit which melts if too large a current passes through the circuit.
   b) It protects the circuit by melting and breaking the circuit.

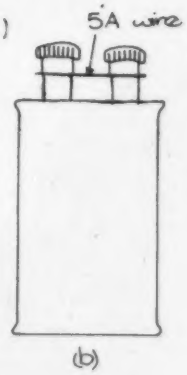
Page 47

DEMONSTRATION EXPERIMENT: The 5A fuse wire

You will need:

a rechargeable cell (fully charged)
a bulb and holder
a circuit board
ammeter leads (2)
a piece of 5A fuse wire (see page 48 in S.G.)


(a)

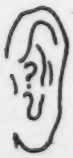


(b)

Assemble the circuit as in (a). Let pupils note the brightness of the bulb and then break the circuit. Connect a 5A fuse wire as in (b). It should get very hot and melt. This breaks the circuit. Repeat (a) again. Ask pupils to note the brightness of the bulb. It will still be as bright as before.

A fuse protects the battery from overheating and running down very fast. A fuse can be regarded as an automatic switch which breaks the circuit if too large a current passes through. It helps to conserve electrical energy in addition to protecting the circuit from overheating and starting a fire.

Page 47



Discussion:

The fuse wire became very hot and then melted and broke the circuit. The current passing through was greater than 5A. Less than 5A the fuse would not have melted.

Page 48

Activity 3: Looking at fuse wires

A 5A fuse wire is used in lighting circuits and a 15A fuse is used in a power circuit. A power circuit draws out more current than a lighting circuit. Power circuits will be dealt with in the next Unit.

Page 49

Exercise 14: The Catridge Fuses

1. What would happen to the ammeter if you replaced its fuse wire with a 5A fuse wire?

2. You want to measure a current in a given circuit using an ammeter. When you include the ammeter in the circuit and complete the circuit, the pointer remains at 0 (zero).

   You suspect that your ammeter is not working.
   a) Are you going to take it straight to an electrician for repairs?

   b) If not what would you check before taking it for repairs?

   c) If you found the fault could you repair the instrument? How would you do it?

   d) What do you then do if, after checking , you found no fault?

Answers

1. The ammeter would be damaged since a 5A fuse wire would not protect it.

2. a) No (because it is costly).

   b) I would check the fuse.

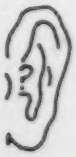
   c) Yes, by replacing the blown fuse by a new one of the same size.

   d) Take the ammeter to the electrician for repairs.

N.B. Question 2 is on general application of knowledge gained.

Page 50

Discussion:



The rate of flow of water depends upon the diameter of the tube/pipe through which the water passes. A thin pipe would allow a very small amount of water to pass through it and a wide pipe would allow a large amount of water to pass through. (Refer to page 44 in S.G.). A thin wire would allow a small current to pass through it.

P

Activity 5: Pupil model of a circuit Page 50

Mark the circuit for Activity 5.
You do not need so many stones/bricks as in the diagram.
You may mark the circuit using a hoe.

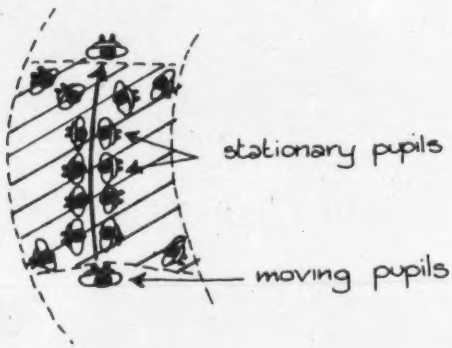
1. Bring the pupils out and tell them to stand in area B.

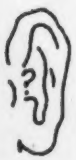
2. Pick about 10 pupils and make them stand in the circuit as indicated. Tell the class that the boys in the circuit represent particles. When they move (flow) they form a current.

3. When you say "GO" the boys move quickly in the circuit. Thus "GO" is the switch in this activity. The 'energy' is provided by themselves!

4. Now say "GO". Let the boys move quickly through the circuit twice. Then ask: Was it difficult to move through the circuit?

5. Then take the remainder of the boys and make them stand very close to each other in area A thus:





Tell these boys that they are fixed and can only be pushed aside with difficulty by moving boys.

6. When you say "GO" tell the moving pupils to move through the circuit as quickly as they can twice. They must pass between the stationary boys. Then ask: Did you move with the same speed as in the first case? In which part of the circuit did you use more energy to move through?
What do you think stationary boys represent in a torch bulb circuit? (Thin wire.)
What does the circuit marked by bricks/stones represent? (Leads.)

You can, if time allows, repeat this Activity with the girls also.

Tell the students to go back to class.

Back in class, tell the pupils to rub their hands quickly for a minute.
What do you (pupils) feel?
How smooth are your palms? (If they say smooth, let them look at their palms using a handlens.)

Let them now read page 51 in S.G.

N.B. On page 51 stationery should be stationary.
Ask pupils to correct it.

Page 52

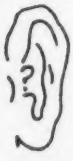
Discussion:

A thin long conductor offers more resistance to the flow of electric current.

Page 53

Discussion:

N.B. The 'discussion ear' has been omitted for the study guide.



Aluminium is very light compared to copper and silver.
If copper/silver were used many strong pylons would have to be used to carry the heavy cables. Because aluminium is light, a few pylons, placed at wider distances between them, are used. This cuts the cost on pylons. It is not just a question of choosing the best conductor. Other factors do come in e.g. price, density etc.

Page 53 to 54

Go through these pages with the pupils and ensure that they understand the relationship between voltage, current and resistance.

You might like to test the pupils by asking them what happens to one of the three when one of the others is held constant and the third is changed.
e.g. (i) What happens to the current if I increase the voltage applied to a particular resistance.
Answer: It increases too.
(ii) What happens to current if I keep the voltage constant but increase the resistance it is applied to?
Answer: The current will decrease.

N.B. Teh should be the. Tell pupils to correct.

Page 55:

HOW MUCH DO YOU KNOW? 2.

Answers

1. p.d./voltage.
2. volt, voltmeter.
3. voltmeter, parallel.
4. sum.
5. It uses a lot of energy to drive the current through itself.
6. It uses very little energy to drive the current through it.
7. a short circuit happens when the terminals of an electrical source are directly connected by a good conductor.
8. It quickly gets discharged and becomes flat/'dead'.
9. a short in the circuit is likely to cause a fire.
10. a fuse is a wire/conductor which melts easily when too large a current passes through it.
11. if too large a current flows through a fuse, the fuse wire melts and breaks. This prevents overheating of the circuit which can cause a fire.
12. (a) nothing will happen to the fuse i.e. it will not break the circuit.

    (b) the ammeter will be damaged by overheating.

Page 56

SUMMARY

Ask pupils to write this in their exercise books.